

Geological Features in Mill Creek Park  
Youngstown, Ohio

As a fulfillment for Geology 570  
and as a partial fulfillment for  
the requirement of a degree of  
Bachelor of Science Degree

*June* 1971

by

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## ABSTRACT

This paper was written as a partial requirement for a Bachelor of Science Degree at Ohio State University. As I was doing my Field work in Mill Creek Park, I would see men taking a short cut through the Park after work at the steel mill, young couples strolling down the paths and others. Most of them can only appreciate the beauty of the Park. Only a select few can appreciate the geological beauty that produced this gorge. This paper was written at a high school level as a tour guide. I hope that the people who read this paper will see the geological beauty in Mill Creek Park.

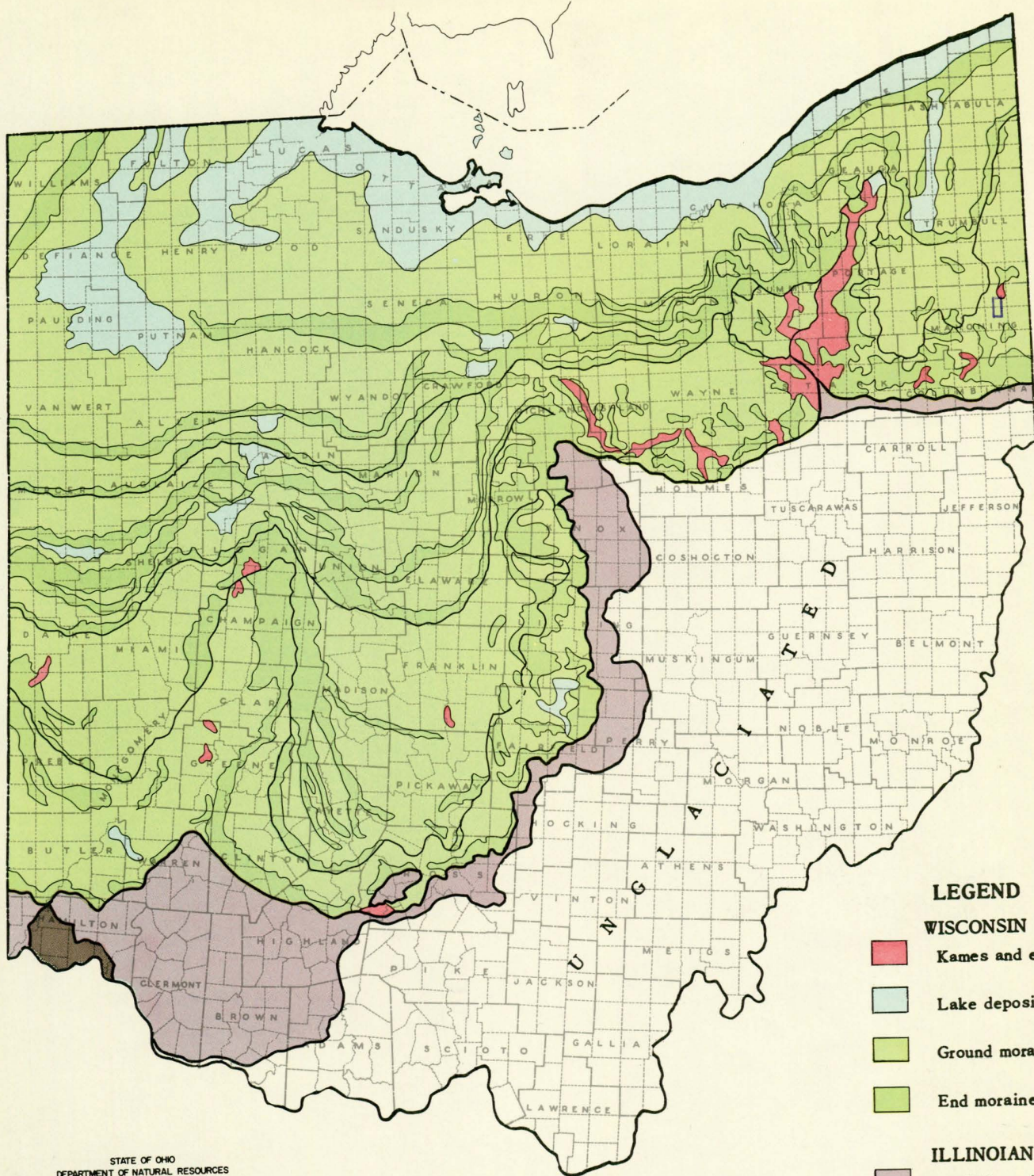
## ACKNOWLEDGMENTS

I wish to thank all those responsible for the production of this paper, especially Dr. Sidney E. White, Department of Geology at The Ohio State University, and Mr. Ernest Vickers, the Mill Creek Park naturalist, for their assistance.

## INTRODUCTION

Mill Creek Park consists of gorges varying in width from a few hundred feet at the Narrows to about a mile in its widest parts. Its natural beauty lies in its alternating deeply cut ravines and its wide valley with alluvial bottoms. Along its cliff walls and lowland plains is an abundant growth of hardwood and evergreen trees. The source is a small spring on Cope Farm at an elevation of 1,175 feet. From this point, flowing almost directly North, the creek, accepting the waters of small tributaries, drains an estimated 80 square miles of countryside descends 345 feet before entering the Mahoning River, and a distance of  $17\frac{1}{2}$  miles.

According to Mr. Ernest Vickers, the Park naturalist, prior to 1928 Mill Creek flowed uninterruptedly from its source to Lanterman Falls impounded the water to form Lake Newport, Lake Cohasset, and Lake Glacier.



# GLACIAL DEPOSITS OF OHIO

## CHAPTER II

### MAHONING COUNTY BACKGROUND

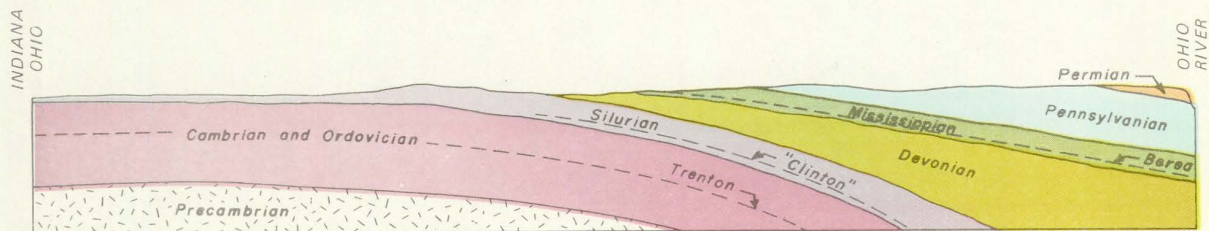
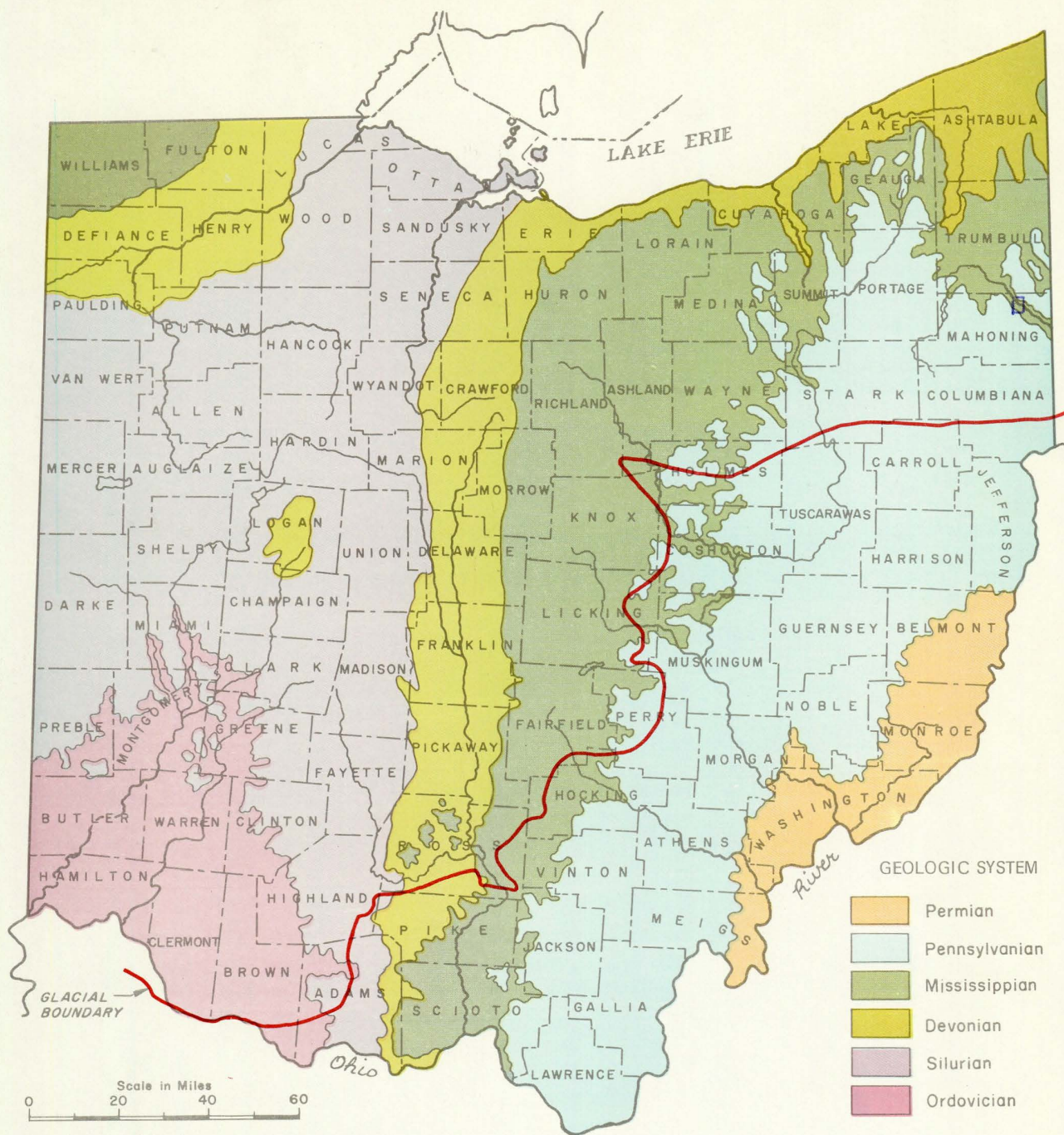
Mahoning County lies in a point of time at a crossroads for its oldest strata outcropping along the Mahoning River from Niles to the State line belongs to one age, the Mississippian and the overlying strata belongs to a later age, the Pennsylvanian. And while the latter of these two groups lies in superposition of the former, many years might have elapsed before the later strata was formed near the border of the inland sea that covered this part of the county.

The older strata, known as the Waverly Group in southern Ohio, but as the Cuyahoga Group in northern Ohio, having been raised up from shallow sea bottom, formed at one time the land surface of this region. (Harper 1948) The topmost member of the group now present in the Youngstown area, the stratum known variously as the Cuyahoga Shale or the Shenango Slate and was for a long eroded by natural climatic agents.

Then came a subsidence (see Sharon Conglomerate) of the land--a gradual and intermitted lowering of the surface until the waters from the sea invaded the land now forming the eastern part of Ohio. But the land did not sink deeply and the waters flooding shallow places formed swamps at different times in which grew dense forest of plant, fern-like palm, and scale trees. Some trees nearly one hundred feet high attained maturity and fell in--to water and decayed.

Thus was formed a thick, increasing layer of carbonaceous matter, until further subsidence permitted this bed of plant





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GEOLOGIC MAP AND CROSS SECTION OF OHIO

material to be buried by beds of clay, sand or lime mud. Then this carbonaceous matter after a long period of time was consolidated into a coal-like substance.

Since the land had been eroded its surface had depressions and high spots; and as the lower parts of the land surface sank a little below sea level, these depressions formed the swamp lands, whereas the high areas were above water level and still dry.

In addition to the formation of coal beds in the swamps of the Pennsylvanian Age, another type of substance was formed, a material that in later years was a main element in starting the Mahoning Valley as an industrial center--iron ore; for into the swamps that covered the lowlands of this remote period, flowed rivers carrying salts derived from the land by the leaching waters that drained off the surface of the emerged land. One of the most essential element so carried by the streams into the swamps was iron.



### CHAPTER III

#### SHARON CONGLOMERATE

Drive into the Park at Falls Avenue entrance and cross Slippery Rock Bridge at the foot of the hill. Turn at the next street and drive to the first ledge of rock at your left close to driveway entrance. (see map)

By looking carefully, a layer of "pudding stone" can be found about eight feet above the driveway. This is the famous Sharon Conglomerate which divides the Mississippian Age from the Pennsylvanian. The Pennsylvanian is the great coniferous coal period of the United States. No coal is found below this Sharon Conglomerate. This is the clearest "unconformity" between these two great ages to be found in Mill Creek Park. Notice that the Mississippian strata seems to dip down to the left and rise to the right.

The Sharon Conglomerate is much thicker when it was deposited in the bottom of old Mississippi valleys. That is the reason the Kennedy Nelson Ledges' cliffs are thirty feet high because these ledges were in an old valley of the Mississippian 250 million years ago. This thin conglomerate is the same formation as the Kennedy Nelson Ledges. Number One coal was laid down on top of the Sharon Conglomerate, and both faded out on the sides of the ancient valley. This spot must have been rather high that no coal was formed over the conglomerate. (Newberry 1878)

## CHAPTER IV

### QUAKERTOWN COAL

The Quakertown or No. 2 coal (Harper 1948) is persistent throughout the Youngstown region, but is generally thin and of no economic importance. It varies in thickness from a simple streak to a maximum of not over two feet. The coal is somewhat thin at places because of the irregular and disconformable material of the Massillon Sandstone, under which it occurs.

The coal exposed west of the Hiawatha Flats (see map) is one foot ten inches with one foot good coal, five inches of dark gray shale and five inches of channel coal. The coal may be chipped out and used for a campfire while picnicing in the park.

## CHAPTER V

### IRON ORE

Since iron plays such an important part in the development of the Mahoning Valley and is very common in Mill Creek, here is some information on the cycle of iron. The iron dissolved by surface waters during weathering moves largely in streams ever onward toward the sea. Some of it may not reach the sea because it may be trapped on route. If the iron bearing solutions contact the early deposited limestones on the way, the iron may be deposited from solution, or organic matter may do the same. Such deposition probably will not give rise to commercial deposits, or if they are likely to be small as in iron ores or impure coal measure beds. For extensive oxide precipitation, the iron in solution must reach the sea.

Marine life, now represented by enclosed fossils, was not dwarfed; therefore, no unusual conditions of environment are indicated. The beds above and below the iron ore beds consist of sandstone and mudrock with some limestone. The sluggish streams, relatively high in iron and low in suspended matter, introduced the iron, which probably carried as a carbonate or as a colloid.

The iron deposition was deposited either in the form of hydrous iron oxide (Limonite) or as a ferric oxide (Hematite). In some places a little calcium carbonate was deposited at the same time, also diluting the iron ore. But since the calcium carbonate or limestone is added to the iron ore in order to settle it, the impurity is not desirable.

Iron ore was one of the chief reasons the Youngstown area developed into a large industrial area. Here is an example of the Sharon ore (Stydson 1932) or "Blackboard Ore". These nodules are chiefly a ferrous carbonate. This ore has little economic value due to its low iron concentration. Occasionally there is found limonite ( $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ) which is a hydrous hematite ( $\text{Fe}_2\text{O}_3$ ). This mineral is light red or yellow and its color is proportional to its Fe content. Some are found in concretions. A concretion is formed if unconsolidated sedimentary matrix is removed from the solution. They start to deposit and can be found in various shapes, spherical, oval, disc-shaped and very irregular if two or more become attached in their growth.



## CHAPTER VI

### MASSILLON SANDSTONE

The Massillon Sandstone directly overlies the No. 2 coal. In general, it is a grey coarsed-grained massive rather fragile on which weathering becomes stained yellow to reddish brown by iron oxide (see weathering in Chap. X). Numerous iron streaks and bands and occasional iron nodule are present in the Massillon Sandstone. The upper part of the Sandstone is usually more bedded than the lower part, and cross-bedding is prominent at places. The Sandstone rests disconformably on its base, often cutting out the No. 2 coal and its clay, as well as several feet of lower strata.

The Massillon Sandstone is patchy in distribution, apparently being a channel fill. Where the coarse Sandstone is not developed, the interval is taken up by arenaceous shale with thin beds of Sandstone.

The best exposure of Massillon Sandstone is from Lake Newport to Lake Cohasset where it is eighty feet or more in thickness. The Sandstone forms high cliffs along both sides of Mill Creek, the valley being very narrow.

The lower part of the Sandstone is massive and show differential weathering. Just below Lanterman Bridge on the eastern side of the valley (see map) there is a great mass of plant fossils in the massive Sandstone mainly Sigillaria and Lepidodendron. Evidently this is a great pile of plant material which was drifted in by the currents and buried in the sand.

## CHAPTER VII

### JOINTS

Joint are cracks and fractures in rock along which there has been extremely little or no movement. Despite the fact that points are so common and have been studied widely, they are perhaps the most difficult of all to analyze. The analytical difficulty is a number of fundamental characteristics of these structures. Thus, there is abundant field evidence that demonstrates that joints may develop at practically all ages in the history of rocks. In sedimentary rocks, joints may develop soon after deposition, while the sediments are still unconsolidated. They may possibly develop towards the end of a phase of active tectonic compression, and be associated with faults and folds. Or they may develop much later, when the phase of active deformation has subsided.

Joints have been classified under two general grouping: those resulting from sheer and those caused by tension. It should be noted that the use of the terms tension joint and shear joint, do not indicate the type of applied force. All rocks, weather sedimentary or igneous from the moment of their origin undergo changes in volume. Sediments formed at the surface are usually soon buried under succeeding deposits, with consequent reduction of pore space and change in volume. If this occurs non-uniformly, strains result and joints may be formed. Later removal of the overburden by erosion permits cubical expansion and many of resulting fractures are tension joints or bedding cleavage. Near and at an exposed surface the volume changes pro-

duced by weathering and repeated heating and cooling must weaken the rock, and since it is relatively weak in tension a multitude of joints are formed.

In examples of tension joints induced by volume change, probably shear is also present. However, the typical joint surfaces are irregular and curved, which helps to distinguish them from any shear fractures which may have been formed at the same time. This means of separating shear fractures from tension joints becomes less dependable if the formation is fine-grained and homogenous like the Massillon Sandstone.

Tension joints associated with compressive stresses are best developed if the confining pressures are not large enough to force the rock to fault along shear planes. This is the case in eastern Ohio caused by the formation of the Appalachian Mountains. Lateral relief (for vertical joints) must be relatively easy. Tension joints can be produced in compression experiments if the compressed surface are free to move at right angles to the direction of maximum pressure.

Although joints may strike in all possible direction, there are generally two directions in an area. After the local pattern has been established the regional patterns should be determined, together with its relation to any other structure which may be present.

By law of least work, failure takes place in a direction of least resistance. A rock joints because it is brittle and because a relatively large increase in rock volume is possible. The major

movement is perpendicular to the joint surface and this denotes a minimum of pressure on this surface. If folding that easy, lateral relief is necessary for vertical jointing. Thus, in folded region, there may be tension in two directions making possible the formation of jointing system. One set, that parallels to the strike of the folds. The other set would be parallel to the direction of the dip would be the result of the stretching brought about the plunge of the folds of the Appalachian Mountains. These sets would intersect at nearly right angles. The strike joints are more strongly developed than the dip joints because of the shallow dip in this area and the distance from the active zone.

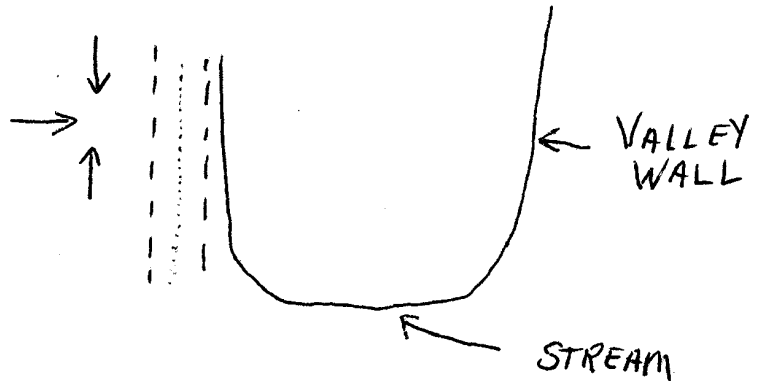
In the coal mining in the eastern part of the state, there are joint patterns in the coal beds. (Ver Steeg 1942) In the northern part of the coal mining area, the joint occur usually in two sets known of the face and the butt joints which lie at right angles to each other. One set extends in the Northeast and the other in Northwest. Farther south, one set extends in a direction of a few degrees west of north and the other set extends in a direction a few degrees west of north or nearly east and west. The joints are arranged in an arc, the convex side to the west. This corresponds to the curve in a folded Appalachian in the central and eastern Pennsylvanian in the same latitude.

The eastern part of the United States were involved in two major orogenies, and the third one in the Permian. This Appalachian orogeny can be dated by determining the age of the youngest strata that are affected by deformation (within the deformed area). This geosyncline had enough energy to cause the jointing

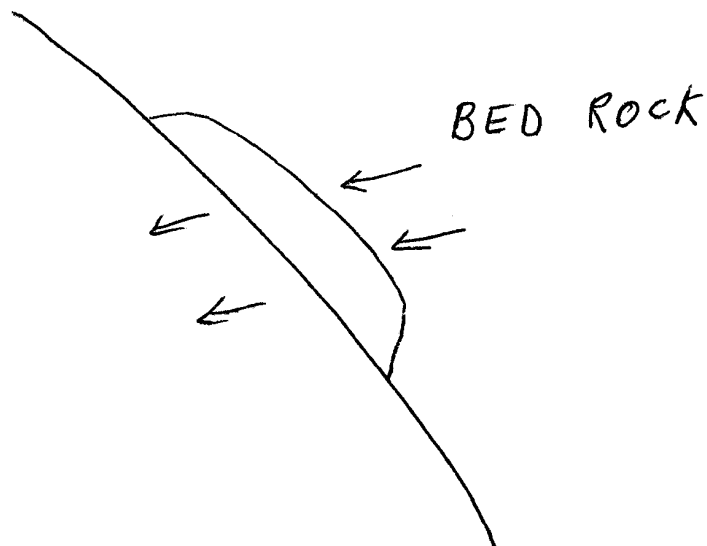


and regional dip in the eastern Ohio.

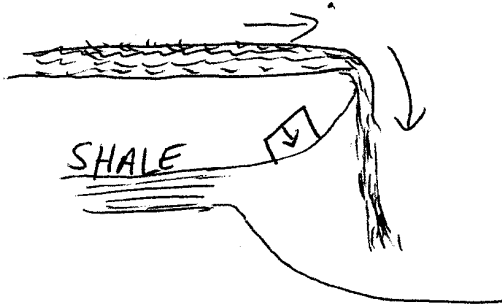
Another joint system to a small scale are the exfoliation joints. These joints are very similar to sheeting joints. Exfoliation joints form parallel to the exposed surface of the rock.



These types of joint occur in rocks of uniform strength and resistance such as granite, basalts, and massive sandstone. According to (Billings 1954) joint is a tensional phenomenon due to the release of load during erosion. The release of the compressional force on specimens that have been under high confining pressure sometime cause rupture perpendicular to the axis of compression.



At Lanterman Falls is a fine example of exfoliation and basal sapping. After walking down behind the Old Mill on the left side of the building, the cross section is exposed.



Stand on the bedrock floor about nine feet up the soft shale is very wet due to high porosity. The shale is poorly consolidated and is easily eroded, called basalt sapping. The exfoliation joints appear to parallel to surface, and will fail when the tension forces are too great.

This is almost the same procedure that occurs at Bear's Den and Witches Cave.

## CHAPTER VIII

### ICE AGE

What lines the streams of this region originally had is conjectured from stream beds found buried many feet below the present surface of the land. It is known that the Mahoning River flowed, not in its present direction, toward the Ohio River, but in reverse, toward the present bed of Lake Erie.

The reversal of drainage lines in this part of Ohio was caused by the great glacial ice cap which moved down from the Laurentian highlands, disrupted all former principal drainage lines, and greatly modified the topography.

The Ice Age, as the period is commonly called, or the Pleistocene Epoch, occupied in time not a single episode of ice invasion but consisted of a succession of ice encroachments over the northern part of the United States. It is known that the ice advanced southward for a period of time, then gradually receded northward as melting took place, the water draining off southward in channels for the most part that were cut by former streams. Upon this melting and recession there followed a stage of milder and warmer climate, known as the interglacial interval which lasted until another gradual encroachment would bring the ice sheet with its lobes southward to work again on the topography of the land.

The advance of the ice cap, known as the Wisconsin Glacial Stage, produced the most pronounced and characteristic marks on Ohio, and all glacial traces in Mahoning County and Mill Creek

bed in the soft material; but its bed from the Hiawatha Flats upstream was solid rock, and this it could not cut into so readily. As a result there was at first a rapid descent of water, possibly a rapids or cataract, at the point where the Lanterman Gorge now begins at the Hiawatha Flats. With time this became more precipitous, the waters carrying away the soft materials in the valley of the Old Mill Creek until they were falling over a ledge and thus became a waterfall.

This waterfall, beginning at the ledge on the southern rim of the flats has, from the time of the recession of the Wisconsin Ice Sheet, been retreating upstream as most falls do. But another fact of geology is demonstrated in this fall of water, since, had not there been a difference in the hardness of the rock stratum, no fall would have been formed, merely a rapids or precipitous flow of water.

So with the steady work of the water itself and the difference in hardness of the underlying strata the falls which began at Hiawatha Flats has, since the recession of the Ice Sheet, worn its way backward to its present position at the Lanterman Mill. And while it has been advancing upstream by the erosive action of the water on the underlying strata, it has also been lowering its bed by simple stream erosion in the rock.

As a contrast to the Lanterman Falls are the Cascade Falls on the west side of the Mill Creek Gorge. Here, waters flowing into the gorge have lowered their bed since the recession of the Wisconsin Sheet, but instead of a single falls developing through marked differences in the hardness of the strata, the water has



material was bitten into by the water of Bear Creek, and gradually the walls of stone were eroded away.

Meanwhile on the opposite side of the rock barrier Mill Creek was swinging in a wide loop against the same hill; and in the course of time, with the two streams working on both sides of the hill, the wall was broken through, Bear Creek flowed in its present direction towards Mill Creek and the former Bear Creek channel was abandoned, became a pool of stagnant water, a geological feature which geologists call an "ox-bow" or "cut-off".

In an east-west direction across the axis of the park north of Hemlock Hill the valley bottom is flat and wide. This open area and subterranean data reveal that when the Old Mill Creek passed over the Goldfish Pond a tributary stream entered the park from the east also. This old tributary valley, filled with glacial debris, was crossed at right angles by the present Mill Creek and the soft materials, here as elsewhere, were easily carried away by the meandering stream.

From their juncture Mill Creek and Bear Creek flowed onward toward the Mahoning River. But instead of taking the course of the Old Mill Creek, the waters of the joined streams cut a new channel --a waterway through the country rock, and not through the glacial drift lying to the west. This new channel and gorge, the "Narrows", again demonstrates the relative difference between the work of the present Mill Creek and the Old Mill Creek which was responsible for the wide valleys.

As the present Mill Creek flowed through the Hiawatha Flats clearing it of the glacial till and debris, it gradually lowered its

also, and the Old Bear Creek, the stream that flowed into Old Mill Creek, was obliterated; and the present Bear Creek, upon the recession of the Ice Sheet, began to flow as an entirely new water-course. But the present Bear Creek, instead of bearing northeastward as its predecessor, flowed almost directly north. Since, however, this line of drainage had been stopped by the glacial debris dumped in the vicinity of the Goldfish Pond, the stream could not pass this point.

The space between the present White Birch Hill and Hemlock Hill was, in effect, filled with a continuous earth and rock-fragment dam which turned the course of the stream so that it made the circuit over the area that was once the bed of the Old Mill Creek and is now the Goldfish Pond.

In its early stages Bear Creek flowed at a higher level, gradually cutting its bed downward in the soft debris and glacial materials to a depth of about fifty feet. Evidences of these higher levels of flow are three stream terraces on the west side of Hemlock Hill--one, the present stream terrace, the second, that terrace on which a roadway is laid, and the third, a clearly defined terrace on the side of Hemlock Hill. Through the ages the stream has continued to cut its way lower and lower.

Owing to the softness of the glacial dam that barred the stream and also due to the direct flow of the stream against this earth dam, it was not long before the barricading materials were cut into, borne away and excavated until the stream gradually etched its way down to the rock strata that was continuous and unbroken between White Birch Hill and Hemlock Hill. But even this harder

time of its rejuvenation, has been bearing away all the earthy fill of the valley that now forms Hiawatha Flats.

By its meandering and its cutting away at its valley walls Mill Creek has laid bare in some instances the path of the Old Mill Creek, for where it encountered stone-walled sides, it was confined within its own valley, but where the Old Mill Creek Valley had been cut and filled with glacial debris, the present Mill Creek could easily eat into and carry away the unconsolidated materials.

Thus was formed the Amphitheater: the present stream, directing its flow against the hill-side, cut away a channel that looped about in the area now forming the Amphitheater; then abandoning this channel the stream took its present course.

What happened in the Amphitheater also occurred in the Cove --that large valley now partially occupied by Lower Lake Cohasset. Here, too, the present Mill Creek found the Old Mill Creek Valley and carried off the glacial materials.

In some cases also the present Mill Creek abandoned altogether the channel of the Old Mill Creek and out across and through the Massillon Sandstones, forming a new or recent valley which is characteristically narrow and definitely contrasted with the valley of the Old Mill Creek.

In the vicinity of the present Goldfish Pond several interesting events took place in geological history. For here two tributaries entered the Old Mill Creek, one from the southwest and another from the east.

The glacier dumped its loads of debris into these old channels

covered by Lower Lake Cohasset and made its way over land and rock now marked by the Goldfish Pond. From here the Old Mill Creek was found to have swept in a broad curve across the lower end of the present Lake Glacier, over Glacier Avenue, Park Way, and Glacier View Avenue, making its way finally to the Mahoning River by a channel west of the Narrows through which the present Mill Creek drains.

This exit channel of the Old Mill Creek left a gap in the Massillon Sandstones approximately north of the lower end of the present Glacier Lake and was found of like size and proportion to the entering portal in the rocky wall of the Mill Creek Gorge. Heaped into this end of the channel, burying it deeply, here as elsewhere, and piled into a thick deposit above it, were the glacial debris--sand, gravel, and boulder clay.

With its old channel filled and clogged with glacial debris, the Old Mill Creek disappeared. It could no longer flow in its buried channel; but with the recession of the ice sheet and the improvement of climatic conditions a new stream started its course, the present Mill Creek, from the beginning following quite closely the course it still pursues.

The present Mill Creek entered more from the southeast and flowed smoothly along the rock strata until it reached at a right angle the glacially drift-filled valley of the former Old Mill Creek in what is now Hiawatha Flats. Here its work was rapid and telling, for with its swift flow the present Mill Creek cut downward in the soft clay and sand, carried away and transported them further along downstream; and by meandering, gradually, since the



and drillings made in valleys and hill-tops. A drill hole was sunk a few hundred yards west of Hiawatha Flats and no rock was reached for 150 feet, indicating that this material passed through was glacial till. At a distance of fifty feet below the present level of the Flats a drill hole indicates that the till is glacial sand and gravel; and though it is not definitely known how far below, the bed of the old creek is, geologists estimate that it lies at a distance of about one hundred feet below the present level of Hiawatha Flats.

Where the Chestnut Hill Pavilion now stands a well drilled for water was sunk 130 feet before bed rock was reached. Since at no other point within the park (except at its north end) does this wide "break" in the Massillon Sandstones occur so definitely, it was concluded that the Old Mill Creek entered the park through this portal in the rock.

Calculations made revealed that the valley of the Old Mill Creek was twice as deep and about three times as wide as the recent or "new" valley of the present creek. The Hiawatha Flats show the width of the old river valley; the gorge that extends from Hiawatha Flats upstream towards the Falls (Lantermann Gorge) represents the work of the present Mill Creek--a sharply contrasted deep valley compared to the wide valley of the Old Mill Creek.

Further search and tracing produced the facts that the Old Mill Creek after entering the park area from the south passed Hiawatha Flats, swung over the land now embraced by the Amphitheater, meandered around and coursed over the lower end of the area now

1500 to 1800 feet thick at its southern edge (near the present Salem) and about 2500 feet high over the Youngstown area, gouged the underlying strata, dumped its loads of debris and rocks and acted like a huge scraper.

A consequence of dumping of glacial materials was a change in the preglacial land surface, especially the filling of valleys and the cutting of new channels from the ice front. Thus came about the reversal of drainage lines, and the Mahoning River, once directed toward the Lake Erie region, now had that channel clogged with glacial debris; instead, flooding backward from the front of the ice, it found an eventual outlet southward along the axis of the Old Mahoning Creek which preglacially had headed near the Ohio Line and flowed northwest to Youngstown.

So were formed new rivers and water courses. And the glacier, dumping and filling, kneading and mashing its loads of soil, rock debris and boulders, covered former drainage lines and buried old channels deeply beneath the present land surface.

In Mill Creek Park the buried channel of an old stream was discovered early in the history of the area. The depth and width of this old stream (as discovered by drill holes) as told by John H. Chase, was of greater proportion than the present Mill Creek stream, and investigations revealed that the present Mill Creek, far from following its ancient forebear, in some cases actually cut new lines of flow across hard sandstone strata.

Evidence now indicates this Old Mill Creek was preglacial, but that its channel was greatly deepened in early glacial time.

The course of the Old Mill Creek bed was traced by borings

Park are attributable to this sheet.

From definite geological evidence it is clear that the work done by the mountains and moving masses of ice changed completely the drainage lines of Mahoning County as well as the land area of northeastern Ohio. Thus, the slope of the county is directly traceable to the work of a southern lobe or tongue of the Wisconsin Sheet which moved downward from the north and excavated the rocky strata that lay between the hard-rocked Conglomerate highlands of Geauga and Portage Counties on the west and the foothills of Pennsylvania on the east.

The materials thus literally gouged from the rocky strata below were turned over, worked, kneaded, crushed, ground and reduced to rock-flour, sub-angular rock fragments and soil. Since the eroded rocks were largely sandstone and conglomerate, the resultant deposits were sand and gravel mingled with clay derived from the crushing and grinding of the Waverly and Erie Shales in the area comprised by Trumbull and Ashtabula Counties, north of Mahoning County.

The working over of these ground deposits formed largely the present soil mantle of this region. For the intimate mixture of sand, clay and rock fragments formed the glacial till or glacial drift that was smoothed into all the depressions of the land as it lay at that time.

The glacier reached a point about twenty-five miles south of Youngstown, and its work was done on the gradual slope of the land over which it advanced, for this region prior to the Glacial Age lost elevation in general northward; and the ice, probably from

worn the rock bed down gradually with a new irregularities;  
and the result has been, not a falls, strictly speaking, but a  
cascade with only two well-defined benches or steps. The Cascade  
Ravine, like all ravines, valleys and gorges eroded since the end  
of the Glacial Period, is another example of a young or new valley.

## CHAPTER IX

### UNDERCUTTING

Falls and cascades are formed generally by the action of water flowing over a harder, onto a softer rock stratum; but another group of agents also produces changes in the sandstone beds. Mill Creek changes the steep walls as it swings against the cliff wall, it eats into its side and removes the rock detritus that weathered off the exposed rock and fallen to the valley bottom. This detritus, the protecting talus, is removed so that the side of the valley is here left steep.

There are two places in Mill Creek Park where huge blocks of rock have been separated from parent ledges. The Suspension Bridge rocks (Witches Cave) on the west side of the Flats are samples of sandstone fallen away from the cliff wall, sometimes separated by only a few feet, often by tunnels.

Most striking examples of this phenomenon is to be found in upper Bear's Den Ravine. Here the most rugged scenery is the huge block of sandstone. According to Naturalist Ernest Vickers, early investigators, on noting this disarray of stone blocks and the number and sizes of them, were led to presume that these were mute witness of the work done when the Wisconsin Ice Lobes were gouging the region.

After a close study of the rock, it is explained that the force was the unimportant Bear Creek which flows among the rocks. At about the present level of the stream the author found a soft

shale, easily excavated and cut away by the running water, such as that which flows in small Bear Creek. Above this shaley layer is superposed a hard sandstone layer, massive in texture and formation. As the stream weaved its way through the valley, it cut away the easily eroded shaley layer and left the heavy overhanging sandstone rock lay unsupported (similarly to the basal sapping at Lanterman Falls); the block of rock would fall off.

## CHAPTER X

### WEATHERING

This sandstone is made up of sand grains, quartz is more or less cemented by other minerals. A diluted solution of HCL was used to test for calcaremite (sandstone with grains of calcite). This rock weathers more like limestone than as a quartzizing sandstone. This massive course, Massillon Sandstone, in weather becomes streaked reddish brown or yellow by the solution of iron oxide. Here we see different weathering. It commonly happens that different parts of the rock weather at different rates. This iron filled joints in the sandstone may be more resistant than the rock itself, and so stand out on a weathered form as "boxwork or honeycomb". Under acid conditions, occasional action of hydration and solution probably occurring for the most part immediately following in frequent showers. This solution is more concentrated in the pits or "nitches" (C. D. Ollier 1969). The resulting fragment may be removed by wind, rain and wet weather rills. This causes the pits to become enlarged.

## CHAPTER XI

### CROSS-BEDDING

In some deposition especially in sands certain beds may exhibit the original lamination oblique to the main stratification. This structure is called false bedding or cross-bedding or cross-lamination. It is generally caused by current action either of wind or of water. It is found in deltas, torrential deposits, sand bars in rivers. This cross-bedding most probably came from a large delta. As the fast moving water in the stream enters a lake the velocity of the stream is dissipated and since the speed descends the ability to carry particles also decreases. Thus we get deposition. First the largest possible are settled out then smaller and smaller particles descend until the very finest clay particles are deposited.



## CHAPTER XII

### PENNSYLVANIAN FOSSIL COLLECTING

On the east side of Mill Creek, just east of Lake Cohasset Dam (see map) is a fine place to collect Pennsylvanian fossils. Lepidodendrids scale trees and Calamities can be found in perfect specimen up to four feet long. These fossils can be collected and removed from the park.

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